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Editorial

Are all earthworms unique and boon to the soil?

Earthworms are amazing. Their habit and habitat, anatomy and histology of the gut, food-retention-time (FRT), castings-production-potentiality (CPP) are different (Singh, 1989). Variations in gut histology may be one of the major causes of occurrence of diverse microbial population. These unusual features of worm's body are enough to prove that earthworms are really unique.

The gut microbes play a major job in the breakdown and disintegration of complex food in addition to the role of intestinal enzymes and mechanical churning of food by the gizzard. Pace of food processing in the worm's gut is dependent upon the number, population and the type of microbes and the worm's species. Several microbiologists have enumerated various microbes and their population densities in different earthworm species but *Metaphire posthuma* and *Eutyphoeus waltoni* – the two common endogeic earthworms have drawn the attention of a few workers only. One of the pioneer researchers, who established the 1^{st} Earthworm Research Laboratory in the School of Zoology at the University of Lucknow, was **Prof. KN Bahl** (1933-34, 1945, 1946 and 1947). He did exhaustive work on the structure and development of their nephredia and physiology of excretion as well as on the habit and habitat and on the moisture content in their castings. This school was again rejuvenated from 1983 to 1993 for Earthworm Research especially on the eco-physiology of these two worms by us. Presently, the School is working at Mahatma Jyotiba Phule Rohilkhand University, Bareilly since 1993 on various aspects of these two earthworms as well as on solid waste management, pollution abatement and organic farming using epigeic earthworms. The article "***Earthworm's Gut: a Rich Source of Microbes***" enumerates an exhaustive study of the gut micro-organisms of *M. posthuma and E. waltoni*. However, some work on the micro flora of *Pheretima posthuma* (now called *Metaphire posthuma)* has been carried out by Srinivasulu (1985). He has reported 14 species of micro fungi from the gut, castings and surrounding soil and noted a gradual reduction in the number of fungal species in antero-posterior direction of these worms.

Usefulness of particular earthworm species is evaluated on the basis of its contribution in improving the soil quality. How much castings an earthworm is producing annually? How much worm - castings is enriched with organic matter, soil nutrients and beneficial soil microbes and how much it makes the soil more porous and aerated as some of the worms are compacting species producing compact castings making the soils harder? Sometimes human - induced biological invasion of exotic earthworms especially those which are compacting species causes adverse effects on the soil health. The other article of the bulletin "***How an Exotic Earthworm Appeared in the Rubber Plantations of Tripura***" is an extensive study on the migration of one of the compacting species. Its' castings has adverse effects on the soil. Such worms are not boon to the soil. Both the articles of the bulletin provide a clue to the earthworm researchers to work more on both categories of earthworms which are either boon or bane to the soil health. Such studies would be helpful to the agrarians in future in segregating those earthworms which are not fit for the farming lands.

Satyendra M. Singh

Message from the President

In the present scenario, when we are facing the problems of deterioration in every corner of the environment, we must plan for such research which should be of general cause and for the betterment of health and hygiene of not only of human beings but of soil, water and air. The research should be for the sustainable development.

I am happy that the University bulletin VERMECO is serving a great role in the transfer of technology from lab. to land for dispersing the new techniques and providing new frontiers of research nearly since a decade. The research articles published are of great interest to earthworm biologists and environmentalists and have a catalytic effect on the research workers to work more on the environmental issues.

The articles of the present issue of the bulletin are of immense importance in evaluating the index of quality of experimental earthworms in improving the soil health.

Prof. Mushahid Husain
Vice Chancellor
Mahatma Jyotiba Phule Rohilkhand University, Bareilly (India)
Former Director, Centre for Nano Science and Technology,
Jamia Millia Islamia, New Delhi

Earthworm's Gut: A Rich Source of Microbes

Importance of a particular earthworm species is generally recognized on the basis of index of its multifarious role in improving the soil health or the pace of transforming biodegradable waste into manure as vermicompost. Several factors are responsible to evaluate such index of the worms. How much digestive enzymes are being secreted and at what pace during the food digestion? What is food-retention-time (FRT) of the gut of worm? What is total gut microbial population helpful in the digestive physiology? These are some of the questions which are not known to all earthworm species.

The role of microbial population during digestion is massive. In an extensive studies conducted recently on two locally available common endogeic earthworms, *Metaphire posthuma* and *Eutyphoeus waltoni* at Earthworm Microbiology Unit of the Department of Animal Science of Mahatma Jyotiba Phule Rohilkhand University, Bareilly, it has been noted that the population of gut microbes was found different in both the worms and their density was varied in pre-typhlosolar (T_1), typhlosolar (T_2) and post-typhlosolar (T_3) regions.

It was observed that in both the worms an axial gradient was found for the microbes from antero-posterior direction of the gastro-intestinal tract. The density of the microbial population was in increasing pattern from the pre-typhlosolar to post-typhlosolar region of the gut of both the worms.

The gradient of increased microbial population (bacteria and actinomycetes) in *M. posthuma* was nearly 3 times in post- typhlosolar region (T_3) than that of pre-typhlosolar (T_1) of the gut; while such gradient was nearly 2.5 times in *E. waltoni.* However, increase in the population density of fungal colonies was nearly 1.2 to 1.3 times in T_3 region than that of in T_1 in the gut of both the worms.

Increase in the microbial population of bacteria, actinomycetes and fungi from pre-typhlosolar to post-typhlosolar region of the gut of both the experimental worms might be due to the completion of mechanical action of the gizzard of the food and availability of digestible food to them in the worm's gut as well as due to differences in their FRT values.

It has also been noticed that there were 3 varieties of bacterial population (*Bacillus lentus*, *Streptococcus porcinus* and *Aeromonas salmonioida*) which have been isolated, identified and found dominated in all the three regions (T_1, T_2 and T_3) of the gut of *M. posthuma*. However, *Escherichia coli* have also been isolated from T_2 and T_3 regions of the worm's gut. There were only 2 species of actinomycetes (*Rothia dentocariosa* and *Nocardia aesteroides*) and 3 fungal species, *Aspergillus terrus, Aspergillus fumigates* and *Thermoascus aurantiacus* which have been isolated and identified from the gut of *M. posthuma*.

In *E. waltoni,* the bacterial population was found more diversified in T_1 region than that of T_2 and T_3 regions. There were 7 species (*S. marcescens, B. pumilus, A. calcoaceticus, A. xylosoxidans, B. lentus, C. hominis* and *E. gergoviae*) in T_1, 5 (*S. marcescens, B. pumilus, A. xylosoxidans, B. lentus,* and *E. gergoviae*) in T_2 and only 1 (*B. lentus*) in T_3 region of the gut; while single species of actinomycetes (*R. dentocariosa*) was found isolated from all the three regions (T_1, T_2 and T_3) of the gut of *E waltoni*. There were 3 species (*T. aurantiacus, A. niger* and *A. fumigatus*) of fungal population which was isolated from the gut of *E. waltoni* out of which *T. aurantiacus* and *A. fumigatus* were found in T_1 T_2 and T_3 regions of the gut. Interestingly the population density of microbes was showing an increasing pattern from antero-posterior direction of the gut like of *M. posthuma*.

Comparative data analyses of the gut microbial population of both worms revealed that *M. posthuma* provides better harbor for them. The total microbial population (bacteria and actinomycetes) was 1.25 times and fungal population was 1.06 times more in gut of *M. posthuma* than that of *E. waltoni.* On the basis of these results, it may be concluded that *M. posthuma* is playing a better role in soil system than *E. waltoni*. More ever, *E. waltoni* is a rain worm and *M. posthuma* is found in the soil round the year.

Table: Population density of microbes (bacteria and Actinomycetes) and fungi in three regions of the gut of two endogeic earthworms, *Metaphire posthuma* and *Eutyphoeus waltoni*

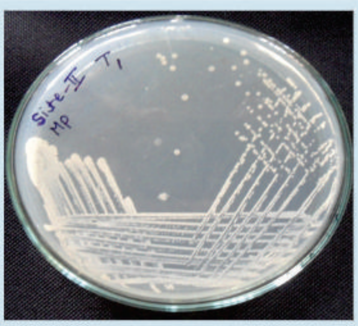
Earthworm species	Microbes	Population density of microbes in cfu/g in three regions of worm's gut		
		T_1	T_2	T_3
Metaphire posthuma	Bacteria and Actinomycetes	1.5×10^6	2.7×10^6	4.3×10^6
	Fungi	6.6×10^5	7.7×10^5	8.0×10^5
Eutyphoeus waltoni	Bacteria and Actinomycetes	1.3×10^6	2.3×10^6	3.2×10^6
	Fungi	6.1×10^5	7.1×10^5	7.9×10^5

How an exotic earthworm appeared in the rubber plantations of Tripura?

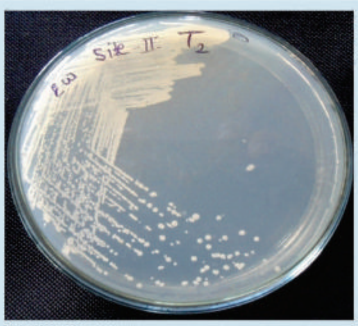
Rubber (*Hevea brasiliensis*) plant, native to Brazil was brought to Tripura in 1963 to check soil degradation due to slash and burn practiced by the local tribal people and also as a part of their rehabilitation program. Our recent research revealed the occurrence of 38 species of earthworms in the soils of Tripura and amongst these 27 species are inhabitants of our rubber plantations. Good canopy is the main factor for rich biodiversity of shade loving earthworms in the rubber plantation in spite of its monoculture nature. Six out of 27 earthworm species of rubber plantations are exotic and the rest native to the Indian sub-continent. Amongst these earthworm species, one exotic species, *Pontoscolex corethrurus* native to Brazil dominated all the rubber plantations in Tripura. However, this is not the only case of invasion of *P. corethrurus* in rubber plantation. There are reports on the occurrence as well as dominance of *P. corethrurus* in the rubber plantations of Malaysia, Burma, Sri Lanka and south India as well (Julka & Paliwal, 2005 ; Nath & Chaudhuri, 2010). It is an established fact that exotic earthworms generally dominate in any disturbed ecosystem which is not usually tolerated by the native earthworm species.

Biological invasions have recently become a major issue in ecology, particularly due to deleterious effect that exotic species may have on the health and functioning of the ecosystems. Invasive species successful at establishment, spread typically with lack of check on population growth leading to important ecological consequences in the long run. Land use history always plays a major role in determining the abundance and community structure of earthworms and establishment of the exotic earthworms in the areas previously inhabited by endemic earthworms.

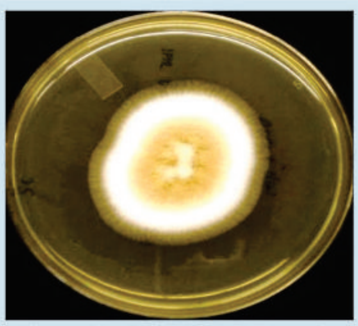
Rubber plantations generally face anthropogenic interferences in the form of taping, latex harvesting, forest clearing etc. Such types of disturbances are generally enjoyed by exotic earthworm species such as *P. corethrurus*. Interestingly, all the disturbed ecosystems of Mexico, Costa Rica, Peru, Brazil, Congo etc are dominated by *Pontoscolex* and there are some instances of total replacement of native species as well (Fragoso *et al.*, 1999).The invasion of exotic earthworms in the tropics can be explained to a great extent by the historical dispersal of humans and commerce (e.g. Trade routes). Reforestation program using root gall planting stock provides another means of dispersal (James and Hendrix, 2004). Transportation of earthworm cocoons through the roots of plants in tropics during British colonization is also another possible means of exotic earthworm dispersal (Chaudhuri *et al.*, 2008). Our recent studies have revealed that total densities (individuals/m^2) and biomasses (g/m^2) of native earthworm species (7 species) were much higher than those of exotic species *P. corethrurus* in young (10 yr old) rubber plantations. Later, total densities and biomasses of native species decreased and those of *P. corethrurus* increased significantly ($P<0.01$) with the increase in the age of rubber plantations. Densities of *P. corethrurus* were 38/m^2, 94/m^2 and 161/m^2 in the 10, 22 and 35 yr old plantation, respectively that comprised 41%, 78% and 96% of earthworm densities in the respective age groups of plantations. On the contrary, total densities (individuals / m^2) of native earthworm species were 54.0, 26.0, and 6.0 in those plantation age groups that comprised of 59%, 22% and 4% of earthworm densities in the respective age groups of plantations. In the 10, 20 and 35 yr old rubber plantations, biomasses of *P. corethrurus* were 14g/m^2, 34g/m^2, 56/m^2 respectively that represented 26%, 58% and 88% of total earthworm biomasses in the respective age groups of plantations. Biomasses of native earthworm species were 39 g/m^2, 24 g/m^2 and 8 g/m^2 representing 74 %, 42 % and 12 % of total earthworm biomasses in the 10, 22 and 35 yr old plantations respectively.Now a question arises, how an exotic earthworm species like *Pontoscolex corethrurus* appeared in the rubber plantations of Tripura- a north-eastern state of India? It is well known that the place of origin of rubber plant, *Heavea braseliensis* was Brazil. Strikingly the original home of *Pontoscolex corethrurus* was also Amazon rain forest of South America (Nath and Chaudhuri, 2010). So it is not unlikely that through the roots of rubber plants *Pontoscolex* dispersed to Malayasian rubber plantations from where the species arrived to the Sri Lankan rubber plantations and from Sri Lanka, *Pontoscolex* probably



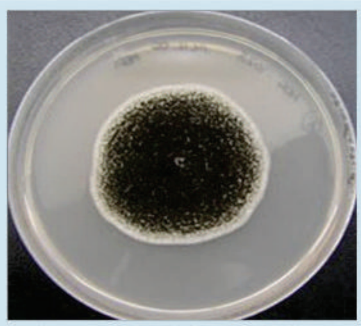
Pure colony of bacteria, *Bacillus lentus* in T_1 region of the gut of *M. posthuma*.



Pure colony of bacteria, A. *xylosoxidans* in the T_2 region of the gut of *E. waltoni*.



Pure colony of fungi, *A. terreus* in T_2 region of the gut of *M. posthuma*.



Pure colony of fungi, *A. niger* in T_2 region of *E. waltoni*.

S.M. Singh - Professor of Earthworm Ecology, Mahatma Jyotiba Phule Rohilkhand University, Bareilly - 243006 (INDIA)

arrived at Indian rubber plantations. In fact, rubber plants in Tripura were brought from Sri Lanka (James Jacob, 2014).

In fact, invasion of exotic earthworms like *Pontoscolex* in tropics (Hendrix *et al.*, 2006) is a matter of great concern. This is because *Pontoscolex* worm is a compacting species producing compact type of cast making the soils harder. In soil ecosystem there is always a balance in population amongst compacting and decompacting species of earthworms; while compacting species makes the soil hard, decompacting species (e.g. *Pheretima posthuma*) ejecting loose granular casts make the soil loose and aerobic. So, dramatic increase in population of *Pontoscolex* and decline in population of native earthworm species is not a healthy sign for the soil ecosystem. Productivity, fertility and biodiversity of soil will seriously be hampered if the native earthworm species are being threatened due to invasion of exotic earthworm species in the soils of Tripura.

Our recent research findings indicated possession of the following biological and eco-physiological characteristics of *Pontoscolex corethrurus* to become a successful invasive species (Nath and Chaudhuri, 2010; Chaudhuri and Bhattacharjee, 2011 and Chaudhuri *et al.,* 2013).

Rubber plantation in Tripura with its dominant exotic earthworm, *Pontoscolex corethrurus*.

- Parthenogenic reproduction: Being hermaphrodite a single individual can multiply producing fertile cocoons without any partner (although earthworms in general reproduce through conjugation and sexual reproduction) (Chaudhuri & Bhattacharjee, 2011).
- Prolific breeder and continuous breeding strategies (Chaudhuri and Bhattacharjee, 2011)
- High assimilation efficiency of the intestine, so that in nutrient poor soil they can survive and reproduce well (Chaudhuri *et al.*, 2013)
- Possesses wide range of ecological tolerance to soil temperature, moisture, pH, organic matter etc (Chaudhuri *et al.,* 2008). Although earthworms, in general are neutrophilic. *Pontoscolex corethrurus* can grow and reproduce well in the highly acidic soils (pH 4.0- 5.8) of rubber plantations.

Policy makers should take necessary steps to control further expansion of rubber plantation areas (presently > 60,000 ha area) and encourage proliferation of plants like bamboos which have tremendous potential in carbon sequestration thereby mitigating climate change.

Priyasankar Chaudhuri - Professor of Earthworm Biology, Tripura Central University, Tripura

Indian Earthworm Biologist-8

Prof. Shibani Chaudhury (b.1956)

Dr. Chaudhury - a Professor at the Centre for Environmental Studies, Visva-Bharati University, Santiniketan (West Bengal) from 2009 did her UG (1977), PG (1979) and PhD (1984) from the serving University. She was heading the Department of Environmental Studies from 2002-2013.

Prof. Chaudhury has started her research career under the supervision of Professor Shelley Bhattacharya, Department of Zoology, Visva-Bharati, Santiniketan, India, from 1980 and awarded Ph.D. degree on "Adaptive and detoxifying mechanisms in a fresh water perch, Anabas testudineus (Bloch) exposed to certain industrial pollutants" in 1984.

She worked as a Scientific Pool Officer (CSIR), at Visva-Bharati University, Santiniketan in Environmental Toxicology Laboratory, Department of Zoology between June 1989 to February 1992 and mainly worked on the i) Estimation of biochemical constituents such as total proteins, total lipids, triglycerides, glycogen etc.; ii) Estimation of glutathione content, metallothionein, glutathione-S-transferase; iii) Estimation of drug metabolising enzymes vis benzo (a) pyrene hydroxylase, aniline hydroxylase, aminopyrine-N-demethylase, ethoxyresorufin-o-demethylase, pentoxyresoruin-O-demethylase, quinone reductase etc.; iv) Electrophoresis; v) Radioimmunoassay of T_3 and T_4; vi) Measurement of ADP and ATP content and release from mammalian cells; vii) Isolation of erythrocyte and platelet membrane. Measurement of blood platelet aggregation; viii) Autoradiography; ix) Chromatography (Thin layer chromatography (TLC), column chromatography and high pressure liquid chromatography (HPLC).

Prof. Chaudhury has owned the crown of several distinctions and achievements in her glorious carrier. Besides the award of National Loan Scholarship of Government of India in 1979 and JRF and SRF of UGC, she was awarded the French Government Scholarship in 1985; PDF of Memorial University of Newfoundland, St. John's, Canada A1B 3X9 in 1985; PDF of University of Mississippi Medical Centre, Jackson, Mississippi, USA in 1987; Young Scientist of DST of Government of India in 1987) and Research Associate of UGC under DSA program in 1995. Prof. Chaudhury has visited 6 foreign countries, Canada, USA, Ireland, United Kingdom, Netherland and Switzerland and participated in 9 International and 56 National Seminars and Conferences.

Presently, she is working on antioxidant effects and bio-remediation by using two species of earthworms, *Eisenia fetida* and *Lampito mauritii* since last more than 15 years and three students have been awarded PhD Degree on Earthworms. She has published 43 research papers in the Journals of repute out of which seven research articles are exclusively on earthworms.

Editor's Office:
Dr. Satyendra M. Singh
Professor & Head
Department of Animal Science, M.J.P. Rohilkhand University, Bareilly-243 006, India. Call at: 09412822490, 0581-2525440
E-mail: editorvermeco@gmail.com, satyendramsingh@rediffmail.com

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